Sestini, Valente, Fabris and Andreocci, the chemistry of santonin. At the same time that he was called to Rome he was made a Senator of the kingdom, and as a moderate Liberal he has taken his share in the consolidation of the constitution of regenerated Italy.

Cannizzaro, when compared with such men as Berthelot and certain of the leaders of the German schools of chemistry, or even with some of the younger generation of Italian chemists, cannot be called a voluminous writer. In all about eighty memoirs have proceeded from his laboratory. It is on the special quality and character of his published work, rather than on its extent, or on the range and variety of its subject-matter, that his fame depends. In this respect he resembles the late August Kekulé. The names of both men will for ever be associated in the history of chemistry with the promulgation of generalisations which mark epochs in the development of chemical science. Cannizzaro's great merit consisted in being the first to clearly point out the bearing on chemical theory of the hypothesis which is commonly associated with the name of his countryman Avogadro, but which Cannizzaro himself, in his well-known lecture delivered before the Fellows of the Chemical Society in 1872, associated also with the names of Ampère, Krönig and Clausius. This, perhaps, is not the time and the place to discuss the question of whatever claims John Dalton may have to be the first to recognise the fundamental truth embodied in the statement that gases, under comparable conditions, contain in equal volumes equal numbers of molecules, whatever may be their nature and their weight. For the moment we are concerned only with the fact that it remained to Cannizzaro to show that the hypothesis afforded the means of placing the most important of all chemical constants—the atomic weights of the elements—on a definable and intelligible basis, and thereby of rendering our conceptions of atoms and molecules, atomic weight and molecular weight, of gaseous volumes and valency, and of all that is associated with or follows from these conceptions, more logical, consistent, and harmonious. What Cannizzaro did, in a word, was to throw light upon what was obscure, to introduce order where all was confused and contradictory. Hence his "Summary of a Course of Chemical Philosophy," published in 1858, will occupy in the history of chemical doctrine a position as a classic, not less honourable than Dalton's ever memorable "New System." There were, of course, difficulties to be overcome, and inconsistencies to be reconciled: certain facts, indeed, appeared to be hopelessly opposed to the hypothesis which Cannizzaro sought to make the corner-stone of the edifice of modern chemistry. But these difficulties have been gradually swept away, and the very facts which at first seemed incapable of being brought into line, are now seen to afford the strongest support to the truth and universality of the theory.

The theory of Avogadro, indeed, has been approached from independent, although converging standpoints, and its position is now secured by the concurrence of independent testimony. Mathematical conceptions of the nature of gases have shown its necessity. Chemical facts, for a time, were seemingly opposed to it, and hence it was neglected and ultimately forgotten by chemists. They were, however, being driven back to it in spite of themselves; and it in no sense detracts from his merit to affirm that even if Cannizzaro had not perceived the truth, the rapidly accumulating mass of evidence would have forced others to recognise it. Indeed the substantial unanimity with which Cannizzaro's doctrine was received, immediately that it became generally known, is a proof that the time was ready for it. It is not too much to say that its effect on the minds of chemical thinkers was as profound as that described by Cannizzaro himself in the memorable lecture before alluded to, when he reminded us of Thomas Thomson's account of the impression produced upon him by Dalton's own verbal explanation of the atomic theory. To paraphrase his words: they were enchanted with the new light which burst upon their minds, and saw at a glance the immense importance of such a theory.

Hence then, when Cannizzaro visited this country in 1872, to deliver the Faraday Lecture to the Fellows of the Chemical Society, of which he has been a Foreign Member since 1862, he spoke to willing and receptive ears, and to a body of men to whom his doctrine was already an established article of their chemical creed.

Cannizzaro is a Foreign Member of many learned Societies; nearly every Academy in Europe, indeed, has delighted to honour him. In 1889 he was elected a Foreign Member of our Royal Society, and two years later he was awarded the Copley Medal for his services to chemical theory. May he long be spared to wear the many honours he has so worthily earned, and to enjoy, in health and increasing prosperity, the respect and esteem of a multitude of friends in both hemispheres!

T. E. THORPE.

EXPERIMENTAL RESEARCHES ON THE PHYSIOLOGY OF REPRODUCTION.

Die Bedingungen der Fortpflanzung bei einigen Algen u. Pilzen. Von Dr. Georg Klebs, Professor in Basel. Mit 3 Tafeln u. 15 Text-figuren. (Jena: Gustav Fischer, 1896.)

IT has long been recognised that in the life cycle of a large number of plants and also of some animals two very distinct modes of reproduction, the sexual and the asexual, recur in a rhythmical fashion.

This fact, crystallised by Steenstrup in his famous doctrine of alternation of generations, has ranked as one of cardinal importance in the treatment of the higher groups of plants ever since Hofmeister showed that the sequence of events in their several life-histories was essentially identical with that obtaining in a moss or in a fern. True it is that in respect of algæ and fungi there existed an uncomfortable *arrière pensée* that all was not quite right, and indeed certain facts seem to be definitely opposed to the general extension of the doctrine to the various members of these classes. Curiously enough it seems not at once to have been clearly apprehended that one has hardly any right to expect to find alternation recurring regularly in these primitive forms; for the very characters which we regard as indicative of primitiveness consist exactly in those negative conditions implied in an, as yet, undeveloped state of division of labour. But it is obvious that, before alternation could possibly have become part of the regular physiological (and morphological) peculiarities of the race, a good deal of initial specialisation must first have occurred ; this will be equally true, whatever view we choose to adopt as to the homologous or antithetic nature of the origin of the process itself.

In the highest forms, we are very far from being able to answer the initial question as to what it is which causes the organism to enter on the reproductive as opposed to the vegetative phase, although as regards the actual phenomena of reproduction itself, we can fairly accurately predict the course which the process will take. But this is merely because it is far less directly affected by the action of the environment than are the functions of nutrition and growth. Nevertheless, although the empirical facts may be easier to glean, their very invariability opposes perhaps the strongest obstacle to our grasping the nature of the chain of causes of which they themselves merely constitute the terminal expression.

But in the lower forms, including most algæ and fungi, the physiological differentiation has not progressed far enough to effect such an adjusted state of organisation as will commonly respond in an identical manner to the action of any stimulus whatever that may happen to be able to excite it at all, for they will either grow vegetatively, or they will reproduce themselves sexually or asexually, according as the exigencies of the environment may demand. It is to them, therefore, that we look to find the clue that shall enable us to penetrate the dense obscurity which at present veils the whole subject.

But although reproduction and the conditions which affect it has long afforded a favourite theme for speculation, its investigation from a scientific and experimental standpoint has been surprisingly neglected. A certain amount of scattered knowledge has been gathered, owing largely to the efforts of gardeners and others practically interested in the solutions of the problems with which we are here concerned, but for definite attempts at thorough investigation by means of inquiries properly formulated and vigorously pursued we have looked, until lately, almost in vain.

Prof. Klebs, then, is the more deserving of the congratulations of all who are interested in these difficult problems on account of the admirable manner in which he has conceived and conducted his elaborate and beautiful series of experiments which are described in the volume before us. For his results conclusively prove that these recondite functions of protoplasm are as amenable to experimental treatment, if approached in a suitable manner, as are those of irritability or of nutrition. It is difficult at present to estimate the exact limitation of Dr. Klebs' methods or the general value of his conclusions, but the results as yet obtained are truly surprising. Instead of uncertainty, we find definite reactions on the part of the organism to varied external conditions, and the present writer can testify to the accuracy of the author's statements in a number of crucial instances.

Of course it is impossible here to give more than a mere sketch of the enormous mass of detailed observation piled up, in a rather unwieldy fashion it must be confessed, in Prof. Klebs' book, but a few typical facts will serve to indicate the general drift both of his methods and his results.

A somewhat large proportion of the entire number of pages is devoted to an account of *Vaucheria terrestris*, of which the author recognises three varieties which showed differences, sometimes slight, sometimes rather striking in the respective manner in which they responded to similar stimuli, but for the details the original treatise may be consulted. The plants were investigated with a view of determining the conditions which govern the formation of the non-sexual zoospores and the sexual gametes respectively, and especial attention was directed to the influence of heat, light, medium of cultivation, organic or inorganic food, and so forth. Dealing with the alga at first from the point of view of its zoospore-formation, a large number of striking facts was elicited. It must be premised that *Vaucheria* only forms zoospores when it is growing immersed in water ; but, as will be seen, this is only a very small part of the story, since the conditions to which it happens to have been previously exposed when growing in terrestrial stations have an important influence in determining whether, on immersion, these bodies shall or shall not be produced. For example, if plants which have been grown on soil in a damp atmosphere be suddenly submerged in water, zoospores are copiously produced within a short time, and this is especially the case if the submergence be accompanied by a darkening of the culture, whereas if a *dry* earth culture be similarly treated zoospores may perhaps not be produced at all. They are, in any case, only formed in the upright filaments, such as may be seen rising up abundantly in any specimens cultivated in damp air. Furthermore, the change from an aërial to an aquatic medium must be a sudden one. A gradual submergence produces no effect, and this fact gives us a probable clue to the cause of the failure of plants which have previously been kept dry to form zoospores after immersion. Under these circumstances the erect filaments are not produced, and by the time they do appear in the water culture, the stimulating effect of the change of medium seems to have ceased to operate.

As regards the action of changes of temperature, it was found that in general a rise of a few degrees provoked the formation of the zoospores, especially when the plants were grown at low temperatures, but that the converse process of cooling was without effect. The interesting discovery was made, that whereas the lowest normal limit at which the plants could thrive and retain their sensitivity was about 3° C., this could be considerably lowered by gradually accustoming the plants to increased cold, and that under these circumstances they still responded to an increase of warmth in the usual manner, *i.e.* by the production of a crop of zoospores.

Much interesting matter is to be found in the pages devoted to the consideration of other conditions affecting the production of zoospores ; but in this place we will content ourselves with indicating some of the more important ones connected with the influence of light. In water-cultures grown under healthy conditions, zoospores are readily produced on the withdrawal or diminution of light. It turns out that plants exposed to blue light behave as in the dark, *i.e.* they form zoospores, but that in yellow rays these bodies are not produced. It might seem natural, at first sight, to connect this peculiarity in some way with the assimilatory functions which are discharged in yellow light; but Klebs decides against this, urging that plants grown in air freed from carbon dioxide behave in the same manner. He does not believe that the small amount of assimilation, which can occur by means of the carbon dioxide set free during respiration, can account for the process. Still, it must be admitted that this is an objection which is not devoid of some weight; and the fact that plants grown in certain mineral solutions *only* form zoospores *during light*, seems to indicate that nutrition may yet be found to lie indirectly at the bottom of the matter. At any rate, a good deal more analysis of the conditions is here necessary before we can safely formulate any theory. Klebs himself goes on to speak of the darkness itself as constituting a *reiz* or stimulus; but it is not very easy to see how a negative condition can be quite appropriately so construed. May not the light, or at least the yellow constituent rays, be regarded as exerting a tonic or inhibitory effect, which must first be withdrawn before the already existing tendency can manifest itself in action? It is clear that the same objection might be urged in the case of some other so-called stimuli; but it seems very desirable to avoid any ambiguity of expression, especially in a subject already so difficult, such as is involved in the use of the word stimulus (*reiz*), both for an active promoting cause and for the removal of a restraining influence.

It is extremely instructive to contrast the conditions which excite the formation, in *Vaucheria*, of sexual or asexual reproductive organs respectively. Whereas darkness is advantageous in the case of the latter, the sexual organs are only produced in the presence of fairly strong light, which further must contain just those less refrangible (yellow) rays which inhibit the production of zoospores. The action of the light is here two-fold. Firstly it operates by promoting assimilation, and in this capacity it can largely be dispensed with, provided suitable carbohydrate food be supplied to the plant. Secondly it acts as a direct stimulus, which initiates the formation of the sexual organs, and in this capacity it cannot be replaced. But when once the stimulus has effected the inception of the sexual organs, they may continue to develop in greatly reduced light, the degree of maturity to which they finally attain being largely determined by the initial duration of the stimulus. In *Vaucheria* the oogonia require a stronger excitation than that sufficing to produce the antheridia; and consequently it is possible, by regulating the illumination, to raise plants bearing only male organs.

Similarly, Klebs determined the corresponding special conditions in the case of a considerable number of other algæ. Several of these are of particular interest as illustrating the individual vagaries and idiosyncrasies of the different species, and also as forcibly emphasising the danger of drawing general conclusions from an insufficiently wide area of facts. For example, *Hydrodictyon* can be induced, as a general rule, to readily reproduce sexually or asexually at the will of the experimenter; but it occasionally happens, as the consequence of certain modes of cultivation, that it develops a very pronounced tendency to form zoospores only, and under these circumstances all the ordinary methods which are commonly efficacious in producing gametes are futile. The plant must first be broken of its tendency to form zoospores; and this can be done by keeping it at a high temperature, and in the dark. This inclination to a particular form of reproduction is of some significance when taken in connection with the difficulty, which is often experienced in many fungi, of securing any but the non-sexual form of reproduction; but it is of still wider interest as once more illustrating the fact that, although external stimuli may evoke this or that form of response, the actual form of the response itself is, after all, not so much determined by the nature of the stimulus as by the particular condition of the special protoplasmic mechanism through which it operates.

Another example may be quoted as illustrating the difficulty of drawing any general conclusion from Klebs' experiments at present. This is not meant by way of disparagement, for his results are in the highest degree useful as affording numerous exact data, even though they hold, it may be, only for isolated individual species. Thus two species of *Œdogonium* were investigated, namely, *Œd. diplandrum* and *Œd. capillare*. Both of these were found growing in the water, often side by side; and yet in hardly a single respect does the stimulus, adequate to provoke the formation of zoospores in the one species, produce a similar effect on the other. The chief differences may be shortly summarised as follows.

(1) In *Œd. diplandrum* a rise of temperature is one of the most effective means (provided too great heat be avoided), whereas in the case of *Œd. capillare* it produces absolutely no effect whatever.

(2) In *Œd. diplandrum* a transference from running to still water produces zoospores, whether in light or darkness; the diminution of oxygen apparently providing the real stimulus here. In *Œd. capillare*, on the other hand, the reaction only occurs in the darkness; the latter condition being, in this case, essential to success.

(3) In *Œd. diplandrum* light is absolutely without influence on the process, whilst in *Œd. capillare* it possesses a powerfully inhibitive action. That mere darkening is not the proximate cause of the zoospore formation, is proved by the fact that the process only begins after a prolonged stay (two days) in the dark; that is, probably, the withdrawal of light allows some change to proceed within the protoplasm, and that the effect of this is to act ultimately as a stimulus to the formation of the swarm-cells.

If anything were needed to show how important is the nature of the protoplasm in each individual instance when considering the result which may follow on identical external stimuli, it would be hard to conceive of a better example than that afforded by the behaviour of these two species of *Œdogonium*. What the nature of the internal mechanism may be, or how the stimuli actually affect it, is absolutely obscure—as obscure, indeed, as are the reactions of the plant to gravity or to the directive influence of light—so soon as we seek to penetrate beyond the region of mere empirical fact. In the case before us Klebs suggests that plasmolysis, and other disturbances of the normal relations of the salts dissolved in the cell-sap, may be the determining factor, but his arguments are not very convincing, and, indeed, such an hypothesis recalls the rough and ready "explanations" which used to be put forward as solving the riddles of heliotropism and the like; but quite apart from this, some of his own direct observations appear to tell strongly against it.

The development of the *sexual* organs in these lower plants is much less variably affected by the influence of the surrounding conditions (a very significant fact, even in these primitive forms) than is that of the non-sexual ones. Light, in greater or less intensity, is commonly essential, and, as has been said in connection with *Vaucheria*, it acts both directly as an initiating stimulus, and indirectly as affecting the function of assimilation. Again, cultivation in a small amount of water, together with the absence or at least scarcity of inorganic nutrient salts, encourages their formation; whilst the addition of the last-named salts commonly suffices at once to check the process, and frequently causes the resumption of vegetative activity.

The case of Spirogyra is of some special interest in this connection, owing to the remarkable disturbances which the addition of appropriate salts may effect in cultures in which conjugation is freely proceeding. These disturbances may take the form, in weak organic salt solutions, of partial arrest of conjugation, the gametes then clothing themselves with a wall while still within their own mother-cells, and finally growing vegetatively as any ordinary separated cell of a filament would do. If, however, the solution be sufficiently concentrated, the gametes develop to form parthenospores indistinguishable, when mature, from true zygospores. Similar effects can be brought about by sugar solutions of appropriate strength. It is important, however, to notice that it is only at certain stages in the development of the gametes that their further development can be arrested, and parthenospore-formation be induced; and this, taken together with the varied behaviour exhibited by the different species, emphasises what has already been said as to the need of taking due account of the "personal equation" of the individual in all inquiries of this kind.

A number of valuable observations on fungi are also recorded in the book; but space forbids further mention of them here, beyond the one fact, which may prove of practical use to teachers, namely, that bread-cultures of *Eurotium* can be made to produce archicarps, &c., with certainty in about two days, if kept at a temperature of 28°—29° C.

Prof. Klebs, whilst mainly concerned with the problems of the physiology of reproduction, incidentally touches on several points of taxonomic interest, and, in particular, he clears up the difficulties which have often been felt with regard to *Botrydium*, by showing that two distinct organisms have been confounded under this name. He proposes to separate them into two genera, retaining one of them in the old genus *Botrydium*, and creating a new one—*Protosiphon*—to include the other.

It is quite impossible within comparatively moderate limits of space to do justice to the great wealth of observation and experiment recorded in the volume before us; the work is essentially one which everybody who is interested in the subject ought to study for himself; and if he finds it rather a bewildering treatise, he will, nevertheless, be amply repaid for his trouble, and may further take comfort from the fact that the author promises another volume in which the points of theoretical interest will be brought more nearly together, and their general bearings discussed. J. B. F.

SHAKESPEARIAN NATURAL HISTORY.

Natural History in Shakespeare's Time: being Extracts illustrative of the Subject as he knew it. By H. W. Seager. 8vo, pp. viii + 358. Illustrated. (London: Elliot Stock, 1896.)

WHETHER, as a student, absorbed in the dry details of systematic work, or whether, as a spectator, interested in the marvellous displays of our museums, we of the present day are too apt to forget that natural history has lost one of the greatest of all charms—the charm of the unknown and the mysterious. To us a new animal merely fills one more gap—it may be large or it may be small—in the chain of nature; its interest, unless it be of striking form and beauty, or have something out of the common in its structure, being generally confined to the specialist. Not so the naturalist (save the mark!) of Shakespeare's day. To him the voyager, on his return to his native land, brought some new legend of the cockatrice, the mermaid, the phœnix, or the unicorn, or told of creatures the like of which had never before been heard of in heaven or earth. It mattered not that *spolia opima*, in the shape of talons, skins, eggs, or feathers, were not to the fore to confirm the story; there the story was, and that sufficed.

Now that the cold light of science has thrown its ray upon the most remote parts of our globe, there is no longer room for legendary creatures—save the sea-serpent; and we are told that the mermaid is nothing more than a dugong, a unicorn either a rhinoceros or a Tibetan antelope, while the cockatrice, the phœnix, and the roc appear to be pure imaginations.

But in the Elizabethan age—an age when the dodo had but recently been discovered—these, and many other mythical creatures, were, if not living, at all events actual realities to the ordinary public, and as such were referred to in the works of the great dramatist and other contemporary writers. We meet, for instance, in the *Winter's Tale* the line, "Make me not sighted like the basilisk," and in the *Tempest*, "Now I will believe that there are unicorns." But not only was more or less of credulity given to the existence of these and such-like fabulous monsters, but a web of mystic lore encircled the most common and best known of beasts, birds, and fishes. Who, for instance, is forgetful of the popular superstitions connected with the salamander, the newt, and the blindworm, and who fails to remember White's account of the "shrew-ash" at Selborne? And if such superstitions still survive among uneducated peasants of the present day, we may be assured that two centuries ago they were fully believed by the higher classes.

As the author states in his preface, the work before us "presents in a convenient form for reference a collection of the quaint theories about Natural History accepted by Shakespeare and his contemporaries. . . . The plan of the book is to give some illustration of each word mentioned by Shakespeare when there is anything remarkable to be noted about it." It is added that the term Natural History is taken to include not only plants as well as animals, but likewise some precious stones. It is further stated, that although Shakespeare had a greater knowledge of natural history than many of his contemporaries, yet that even he gave credence to many